Wheelchair Neuro Fuzzy Control Using Brain Computer Interface

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Abstract— ***The design and implementation of a real-time computer control of an electric wheelchair for physically disabled people is presented. This design is based on brain-computer interface that receives and processes the electroencephalographic (EEG) signals to classify the required commands to drive the wheelchair. Neuro-Fuzzy technique has been used in the controller design for actuating motors of the wheelchair. This controller depends on real data received from obstacle avoidance sensors and brain computer interface. By combining the concepts of soft-computing and mechatronics, the implemented wheelchair has become more sophisticated and gives people more mobility.***

Keywords: *Wheelchair Control, EEG, BCI, Real-time Control, ANFIS, Mechatronics.*

I. INTRODUCTION

More than 35 million people suffer from paralysis and disability that makes them physically unable to interact naturally and contribute to the demands of life [1]. In order to help this large segment of society to do their daily work, many attempts have been made to employ modern technology in computers and communications to build smart systems that suit their needs. The most important need for the handicapped people is the wheelchair and the way to control it easily to enable him to improve his life. Electric wheelchairs are very useful for people who cannot move their bodies freely [2]. These wheelchairs need to be equipped with real-time computer control unit and set of sensors for navigation and obstacle avoidance tasks.

Recently, human brain control of wheelchairs has attracted great attention due to advances in sensors, computers and communication technologies [3,4]. A brain-computer interface (BCI) provides a communication channel between a computer and the human brain. With the advances in computers, sensors and communication technologies, a new field of research has emerged by understanding different functions of the brain to serve people suffering from disabilities. An important problem that constraints the design of an interactive human-computer interface is the availability of appropriate sensors and the computer abilities to process signals to achieve the desired results at minimum time. Also, it is bounded by the inherent abilities of humans to analyze, store, and interpret information to create behavior; and by limitations in the ability of computers to predict human intentions for mobility and communications [5].

The detection and processing of human brain signals to generate commands is the domain of many researchers over the past two decades, where many published papers and commercial BCI products are available [6,7]. Therefore, the main objective of this research is to use such BCI units in the design and realization of a real-time controller for intelligent wheelchair.

The history of BCI began with the discovery of human brain electrical activity and the development of brain electroencephalography (EEG). These EEG signals are useful to detect the human emotions [8]. The implementation of soft-computing tools, such as fuzzy logic and ANN, in predicting wheelchair direction based on EEG signals makes it very attractive for engineers to design and implement smart wheelchairs that suit the requirements of the disabled and elderly people [9,10]. Siswoyo et.al.[10] proposed a 3-layer ANN to develop the mapping from input (generated from sensors) to three commands; turning right, turning left, and forward. Fattouh et. al. [11] proposed an emotional BCI control system to drive a smart wheelchair through four commands in addition to the emotional state of the user. If the user is satisfied, the specified command is still executed; otherwise the controller will stop the wheelchair and ask the user to select another command.

Rojas et.al [9] present an obstacle avoidance controller implemented in a field programmable gate array for an electric wheelchair. The proposed algorithm uses data from eight ultrasonic sensors distributed around the wheelchair to make navigation decisions. The power consumption was evaluated, and it was found that the hardware architecture reduces the battery life by only 0.87%.

Velasco-Álvarez and Ron-Angevin [12] discussed the danger when a wrong command would involve in a real-time control of a wheelchair. Virtual reality techniques is a suitable tool to provide subjects the opportunity to train and test the application before using it under real conditions.

Patients can control the wheelchair simply by moving a part of the body, or by using voice, or by using brain signals. Currently, BCI based on EEG signals, is considered as an effective way to enable people to control wheelchairs. Many control techniques are applied to drive the motors of the wheelchair according to the captured signals from brain [13.14]. In this research, the control part of the wheelchair will be considered rather than the design of the BCI. In this case the brain headset and its related software will be used as complete unit in the proposed design. Khare et.al. [14] proposed an attempt to control direction of a wheelchair via brain signals. They detected the changes in the EEG patterns due

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